TOWARDS A GLOBAL APPROACH FOR THE CHARACTERIZATION OF IC's AND ON BOARD SHIELDING COMPONENTS

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Abstract: Due to the impact of higher and higher frequencies, the direct radiated effects of components on a PCB are becoming important. For this reason, an appropriate SE characterisation of small in-circuit enclosures and the accompanying shielding gaskets at frequencies above 1 GHz is needed. Although the standard IEEE Std 1302™ and the standard IEEE Std 299™ are dealing with SE measurements, even up to the higher frequency range, the methods proposed in these standard are not applicable for these type of shielding components. A method overcoming this problem is proposed in this paper.

1. INTRODUCTION

Due to the impact of higher and higher frequencies, the SE characterisation of small shielding enclosures and accompanying shielding gaskets at frequencies above 1 GHz is needed for on board shielding applications. On board shielding is an application where noisy components must be shielded, in order to cause no interference with the environment (far field) or with adjacent electronic components (near field). The quality of shielding strongly depends on the way conductive contact is made from the small enclosure (CAN) to the ground plane of the PCB. In some cases, a thin gasket is needed to ensure good conductive contact. Although the standard IEEE Std 1302™ and the standard IEEE Std 299™ are dealing with SE measurements up to 18 GHz, the methods proposed in these standard are not applicable for these type of small enclosures and thin and small gaskets.

A typical on-board shielding realization is shown in figure 1. It is clear that the overall SE value will be strongly influenced by the quality how the sixth wall of the shielding enclosure is made, by contacting the GND plane of the PCB to the enclosure itself. This is done by the application of a large number of VIA's connecting a surface trace to the buried GND plane(s), and the use of appropriate clamping techniques, fixing the enclosure on the PCB and making conductive contact with the GND surface trace. Typically, a small gasket is inserted for this purpose.

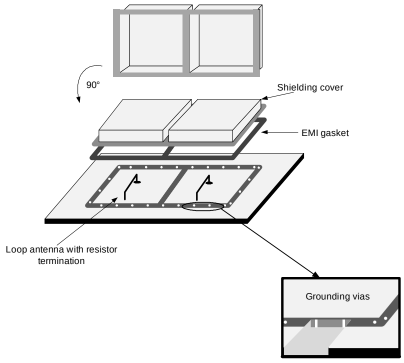

Figure 1. Typical configuration of on board shielding

2. MEASURING METHODS

Actually, a number of possible measuring methods are proposed and discussed in literature [2]. Most of them are based on a modified MIL-DTL-83528C-2001 methodology [3], or the use of a reverberation chamber, or near field measurements.

The general setup for MIL-DTL-83528C-2001 methodology [3] and similar configurations is shown in figure 2. A hole is made in one wall of a shielded (anechoic) room, and a plate is clamped against this opening, compressing a gasket in between the clamping plate and the wall.

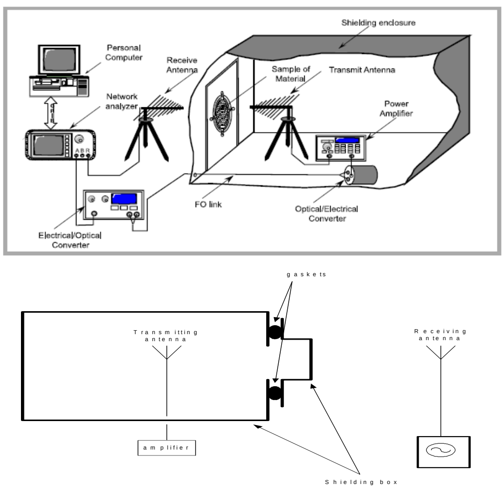

Figure 2. Global and detailed view of MIL DTL 83528C setup and similar configurations

Although a well established measuring methodology, it is not well suited for the characterization of small gaskets intended for on board shielding use.
Another method is based on measurements performed in a reverberation chamber. Different approaches can be used for setting up a measuring configuration in a reverberation chamber. One is using a horn antenna at higher frequencies, another one is using a small monopole probe, mounted on one of the walls of the reverberation chamber. The latter one is shown in figure 3.

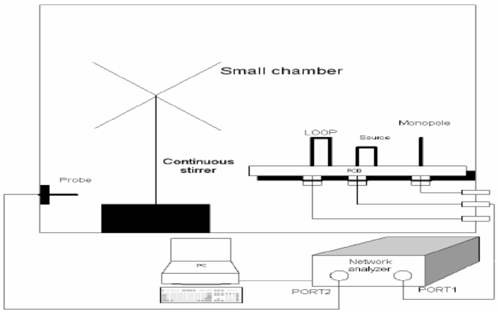

Fig. 3. Configuration of a mode stirred reverberation chamber, using a monopole probe in the frequency range 1 – 6 GHz.

In this case, small loop and/or monopole antenna's are used as transmitting sources or receivers. The main problem is the fact that these small antenna's are not matched to 50 Ohm in the frequency range of interest.
Instead of the environment of a stirred reverberation chamber and its antenna configuration, a second set of on-board antenna's can be used. The equivalence of measured SE values between reverberation chamber setup and near field testing, has been reported.
Due to the small size of the antenna's, the method has a restricted dynamic range, which might imply the use of a high power amplifier.
Furthermore, these methods does not fit directly to an on-board application of the gasket for PCB level shielding.

3. NOVEL MEASURING METHOD

In order to overcome some of the disadvantages mentioned in section 2, another setup has been developed.
Recently, an interesting test methodology has been proposed for susceptibility and emission testing of IC's: IC stripline method [4]. The method is based on putting a stripline over a PCB board with a full GND layer, so that susceptibility or emission of an Integrated Circuit may be performed. The principle of the setup is sketched in figure 4.

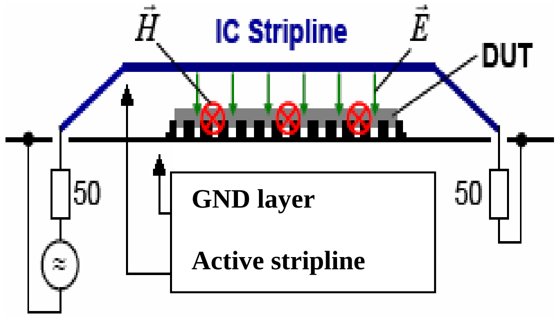

Figure 4. Principle setup of the proposed stripline method in Order to characterize IC's

By replacing the IC under test by a 50 Ohm microstrip, similar measurements may be performed for the characterisation of small enclosures and small gaskets, which are intended for on-board shielding.
In case of a small enclosure, a microstrip is etched on a PCB, and will be covered by the box under test. In case of a small gasket, a solid plate to clamp and compress a gasket to the chassis of the system, is inserted in the system. In this way, a measuring setup is obtained, with a direct relationship to the physical, mechanical and electromagnetic environment of on-board shielding.

The proposed measuring setup is shown in figure 5. The system has an overall size of 17x20 cm.

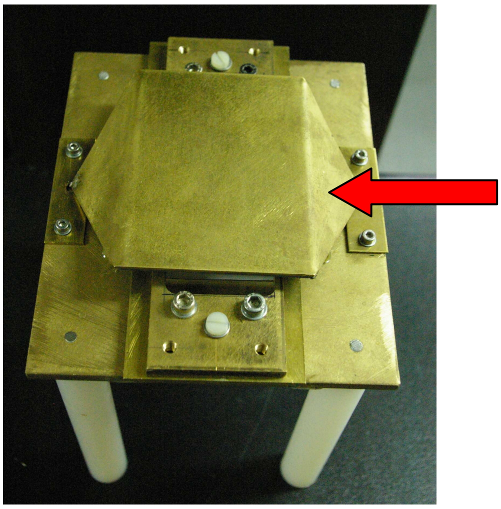

Figure 5. Overall view of the stripline setup

A stripline has been designed to fit a characteristic impedance of 50 Ohm (red arrow). The width of the stripline is 12 cm and the height above the solid GND copper plate is 2.6 cm. The active length of the stripline is 9 cm, and both tapering sections are 3 cm each. The inner side of the stripline is covered with an absorbing ferrite sheet, to avoid too much influence of the short tapering. SMA connectors are mounted through the solid GND plate.

3. SMALL ENCLOSURES

In this case, a microstrip structure is etched on a larger PCB, carrying the stripline structure as well. The complete concept is shown in figure 6.

Figure. 6. Microstrip (upper), covered by the PCB-level enclosure (middle) and the stripline (lower) of this set up

The main advantage is that the microstrip, acting as the internal antenna in the enclosure, represents a wide band matched (to 50 Ohm) structure. The small CAN used for this purpose is from Laird Technologies and the size is 52mmx48mmx14mm.

A first set of measuring results up to 3 GHz is shown in figure 7, and the difference between both traces represents the SE value, which is about 30-40 dB for this specific enclosure.

Figure 7. Measurement of the induced signal in the stripline: upper trace for the naked microstrip (no CAN) and lower trace for the shielded microstrip

The method looks well promising, and the setup does not require large space or special measuring rooms. For a first validation of the concept, the results are compared with a well established method, based on IEEE Std 299™, and has already been referred in figure 2.

By covering the window of the metal enclosure with a PCB carrying the small CAN, the related shielding may be measured using this same concept. The open window, showing the horn antenna inside the large enclosure is shown in figure 8.

Figure 8. Large open window of the metal enclosure, and showing the horn antenna inside the enclosure

A massive copper plate, with a small opening, is mounted on the large window. On this plate, the PCB and its small CAN is mounted. The next pictures show the open CAN, and the closed CAN, as mounted in the measuring set up.

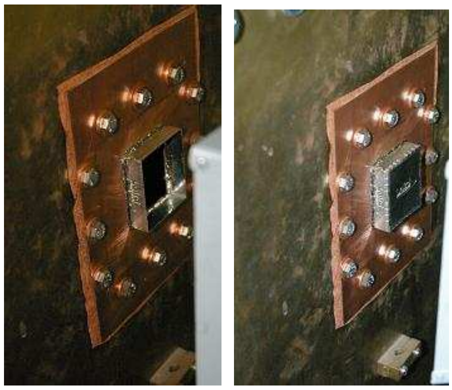

Figure 9. Open CAN (left) and closed CAN (right) as mounted on the PCB, which is fixed on the large enclosure

Measurements were performed in the frequency range from 1GHz up to 6 GHz, and are given in figure 10. The upper trace is the signal level for the open CAN, the middle trace is the signal level for the closed CAN, and the lower trace is the noise floor of the measuring system.

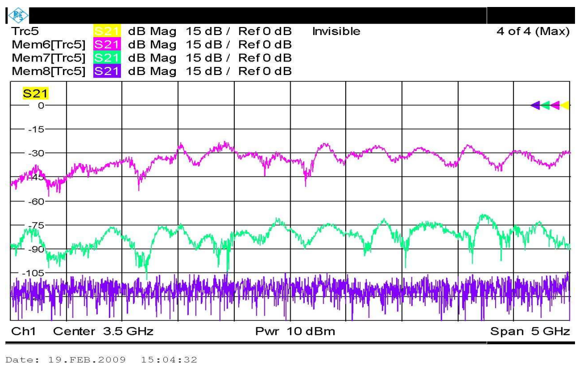

Figure 10. Measuring results for the modified IEEE 299 method

From these measuring results, an estimate of 30-40 dB can be made for the SE value of the PCB and the CAN, which is in good agreement with the stripline method.

4. GASKETS

The method is also applied to small gaskets, as shown in the next pictures.
Embedded in the solid GND plate, there is a small 50 Ohm microstrip, with a matched load of 50 Ohm connected via an SMA connector through the GND plate. This microstrip is used as the transmitting antenna, and simulates the radiating traces on a virtual PCB. The microstrip has a length of 4 cm and is made on a substrate of microwave PCB material, and is embedded in a 5x5 cm opening.

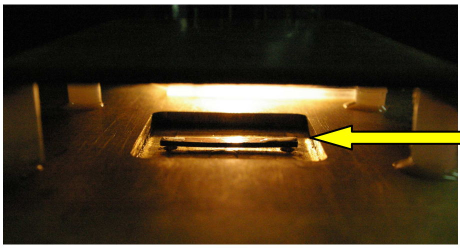

Figure 11. Embedded microstrip

By covering this embedded microstrip with a plate or sheet, the Shielding Effectiveness (SE) of this material can be evaluated, by performing two measurements: a first coupling between microstrip and stripline in an open structure and a second one when covered with the material.
Using a solid copper plate to cover the embedded microstrip, and inserting a gasket in between this plate and the solid GND plate of the stripline structure, the SE of the gasket can be measured. In this way, the copper plate can act as a gasket sample holder, and the gasket may be carefully positioned on this solid plate. This is shown in figure 12. When placing this sample holder in place, the embedded microstrip is exactly within the inner surface area limited by the gasket.

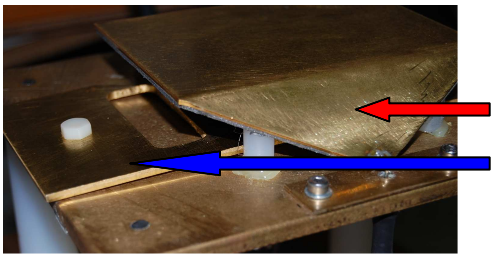

Figure 12. Detailed view of the stripline setup

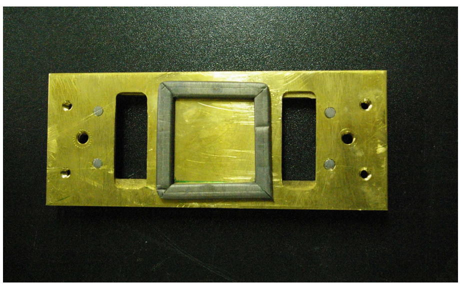

Figure 13. Solid copper plate acting as gasket sample holder

5. PRELIMINARY VALIDATION (8 GHz)

Due to the availability of measuring equipment, a preliminary validation of the system was performed up to the frequency of 8 GHz. For these measurement purposes, a vector network analyser (VNA) has been used, which enables the measurement of the 4 S-parameters of the system.
The 4 S-parameters for the open system are given in figure 14, showing the relatively fair 50 Ohm design (S11 and S22) and the coupling between the microstrip and the stripline (S21).

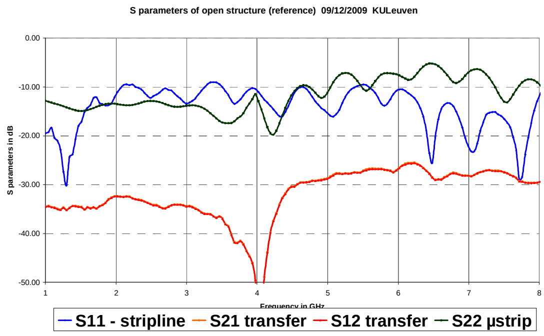

Figure 14. S-parameters of the stripline setup

A sharp resonance is observed around 4 GHz, and which can not be directly allocated to a typical dimension of the system.
For the purpose of this paper, an example of the obtained measuring results is reported for one type of gasket: Dynashear™ from SEM.
The VNA allows to calibrate the measured S21 parameter of the open structure as reference, so that further measurements of S21 will directly show the SE levels of the configuration under test. The gasket was fixed on the sample holder, as can be seen on the picture of figure 13.

Three different cases have been tested:

- inserting the sample holder, without further compression of the gasket (green line)
- compressing the gasket down to a thickness of 1 mm (blue line)
- inserting an insulating paper sheet between the compressed gasket and the solid base plate, so that no conductive contact is realised (red line)

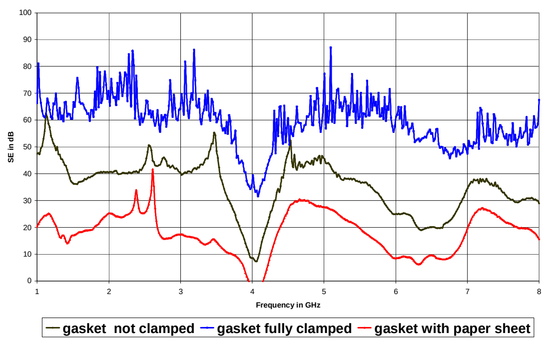

Figure 15. Typical set of SE values

Three main effects may be observed:

- a clear discrimination between the 3 different cases, showing the importance of making and maintaining a good conductive contact between both parts of a shielding system
- even by calibrating out the sharp resonant effect in the open structure, it is still present when performing the SE measurements
- when a high level of SE is obtained (fully compressed gasket), the dynamic range of the measuring equipment is exceeded, and a very noisy result is obtained. This might be overcome by the use of an extra amplifier in the transmitting chain.

Other mechanical problems were identified and corrected in a final version of the setup. First of all, in order to ensure that no conductive contact could occur when the sample holder was screwed to the base plate, plastic screws were used. However, due to the high forces needed to fully compress the gaskets, they show some elongation because of the elasticity of the plastic.

To ensure no conductive contact at the screwing area, insulating sheets were mounted, and metal bolts are now used, within a small plastic tube. The exact compression is now controlled using plastic spacers of different thickness, that can be inserted between the sample holder and the base plate.
The new mechanical design is shown in the next pictures.

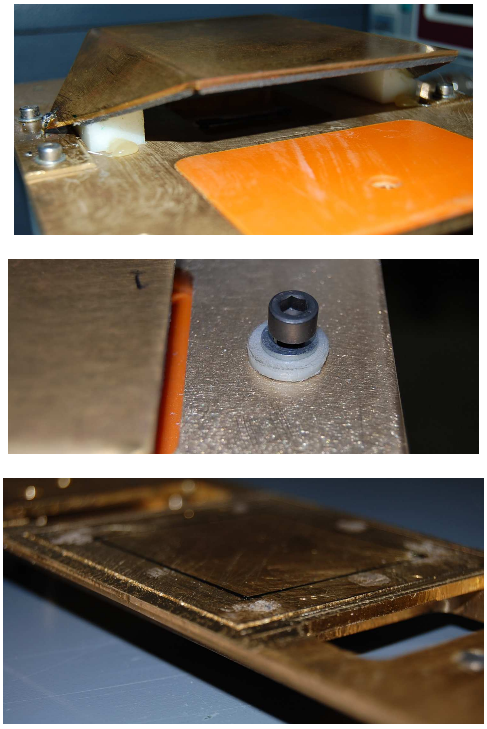

Figure 16. View of the insulating sheet, to avoid conductive contact between holder and base plate (upper), metal bolt in a plastic tube to compress the gasket (middle) and visible alignment for exact positioning of the gasket (lower)

6. FINAL VALIDATION UP TO 18 GHz

A final validation of the stripline fixture has been performed with an appropriate VNA up to 18 GHz. Unfortunately, at the moment of these measurements, no amplifier up to this frequency was available.
It means that the dynamic range of the measuring setup is limited, and that high performing shielding gaskets will show a noisy measuring result.
The S-parameters of the stripline fixture are given in figure 13.

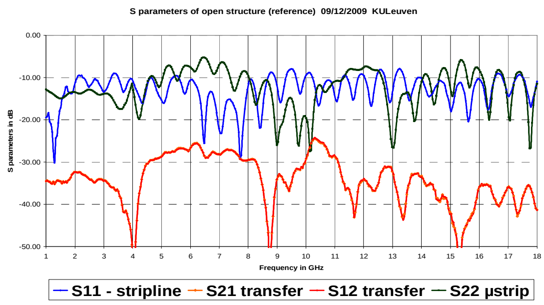

Figure 17. S-parameters of the stripline setup

As an example, the measured SE values of the same type of gasket as used for the preliminary testing, are given in figure 18.

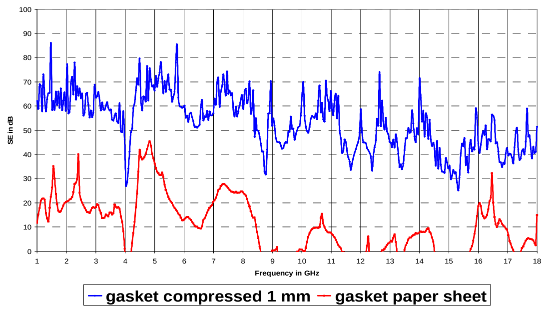

Figure 18. SE values of a compressed gasket up to 18 GHz

CONCLUSIONS

A novel test fixture for the characterization of on-board PCB shielding components up to a frequency of 18 GHz, has been discussed and validated.

References

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[3] MIL-DTL-83528C-2001, "General Specification for Gasketing Material, Conductive, Shielding Gasket, Electronic, Elastomer, EMI/RFI", 2001

[4] B. Koerber et al., "IC-stripline: a new proposal for susceptibility and emission testing of IC's", Proceedings EMCcompo 2007